[0027]

Next, image signal processing used in image forming device of the present invention will be described. The image signal processing is to replace distribution of density data of adjacent pixels including one pixel of interest with distribution of small pixels of m × n (horizontal × vertical) within said one pixel wherein the pixel of interest in image density data comprises small pixels of m × n, to calculate record location data from a density centroid for each line of small pixels based on image density data of small pixels obtained by distributing data of a pixel of interest multiplied by a certain constant P according to the above-mentioned distribution, and to perform image formation by displacing a dot writing location of n lines. This displacement of a dot writing location is called a record location modulation here. The process of converting the above-mentioned pixel of interest into image density data of small pixels, which divides the pixel of interest into m × n, is called resolution enhance process (RE process) here. This RE process enables high density record. In this case, high γ photo conductor is effective particularly on latent image formation by laser writing device.

[0028]

According to the present invention, this RE process (1) is performed where density data of a pixel of interest is a first threshold or more, i.e., a particular density, the first threshold, or more. In other words, an RE process

is not performed on a background of a manuscript for many regions corresponding to a highlighted part and the density of small pixels of m × n is considered uniform. For CRT, this display of data is possible. However, since uniform display is difficult for later described laser record, a pulse with a record location in the center of pixel is generated in such a case. This maintains uniformity within a highlighted part and prevents occurrence of an image with a lot of noises.

[0029]

(2) On the other hand, if a density grade is great at a high density part when a record location of density is generally not in the center, dots are formed across adjacent pixels. In the present invention, dots formation that does not affect on adjacent pixels is performed, though a pulse with a record location in the center of a pixel is generated in the case of a particular second threshold or more even in the high density part in order to prevent density fluctuation and a record dot collapse between pixels.

[0030]

Since uniform display is possible for CRT, small pixels of m × n are processed as in uniform density. In other words, an RE process is not performed on them.

[0031]

That is to say, an image forming device performing high density pixel record with density distribution data within a pixel of interest depending on density data of pixels

adjacent to the pixel of interest, characterized by performing a record location modulation based on said determined density distribution when a particular density data of a pixel of interest is a first threshold or more, and further characterized by performing a record location modulation based on said determined density distribution when a particular density data of said pixel of interest is a second threshold or more is preferred.

[0032]

Figure 10 (a) is a plane view, in which the above-mentioned pixel of interest is denoted by m5 and adjacent pixels including the pixel of interest m5 are denoted by m1-m9 wherein the pixel of interest m5 is divided into 3 × 3. Figure 10 (b) is an enlarged view showing a pixel of interest m5 divided into small pixels of 3 × 3 wherein each small part is denoted by s1-s9. m1-m9 and s1-s9 also represent density of respective parts.

[0033]

An RE process will be described in detail. Assuming the above-mentioned pixel of interest m5 being divided into small pixels of 3 × 3, density of small pixel si is determined by the expression below:

[0034]

$$si = (9 \times m5 \times P \times mi/A) + (1-P) \times m5$$

where i=1, 2, ... 9, P is a constant representing an intensity of an RE process, preferably ranging from 0.1 to 0.9. Even

in the case of P=1 to simplify the process, there will be an effect to some extent. A is the sum of m1-m9.

[0035]

In the above expression, the term (9 × m5 × P × mi/A) is density of a pixel of interest m5 multiplied by P and divided according to the rate of density of adjacent pixels. The term (1-P) × m5 is the remaining density of the pixel of interest m5 equally divided for each small pixel, i.e., a factor of blur is taken into account.

[0036]

Figure 11 is a diagram showing an example of a pixel of interest m5 divided into 3 × 3, where P=0.5. Figure 11(a) is a diagram showing an example of density distribution within adjacent pixels including a pixel of interest m5, and Figure 11(b) is a diagram showing a density distribution within a pixel of interest m5, where P=0.5.

[0037]

Figures 12 and 13 show examples of a pixel of interest m5 divided into 2 × 2.

[0038]

Figure 12 (a) is a diagram showing an example of a pixel of interest m5 divided into 2 × 2, and Figure 12 (b) is a diagram showing an example of adjacent pixels associated with small pixels s1-s4 within a pixel of interest.

[0039]

Density of s1, s2, s3, s4 is calculated according to expression 1.

[0040]

[Expression 1]

$$s1 = 4m1 + 2\ (m2+m4) + m5\ /A \times m5 \times P + (1-P) \times m5$$

$$s2 = 4m3 + 2\ (m2+m6) + m5\ /A \times m5 \times P + (1-P) \times m5$$

$$s3 = 4m7 + 2\ (m4+m8) + m5\ /A \times m5 \times P + (1-P) \times m5$$

$$s4 = 4m9 + 2\ (m6+m8) + m5\ /A \times m5 \times P + (1-P) \times m5$$

where A is the sum of m1-m9.

[0041]

Figure 13 (a) is also a diagram showing an example of a pixel of interest m5 divided into 2 × 2, and Figure 13 (b) is a diagram showing another example of adjacent pixels associated with small pixels s1-s4 within a pixel of interest. Density of s1, s2, s3, s4 is calculated according to expression 2.

[0042]

[Expression 2]

$$s1 = m1+m2 + m4+m5\ /A \times 9/4 \times m5 \times P + (1-P) \times m5$$

$$s2 = m2+m3+ m5+m6\ /A \times 9/4 \times m5 \times P + (1-P) \times m5$$

$$s3 = m4+m5 + m7+m8\ /A \times 9/4 \times m5 \times P + (1-P) \times m5$$

$$s4 = m5+m6 + m8+m9\ /A \times 9/4 \times m5 \times P + (1-P) \times m5$$

where A is the sum of m1-m9.

[0055]

RE processing circuit 240 includes 1 line delay circuit 242, 1 clock delay circuit 243, operation circuit 241 as shown in Figure 5. With 1 line delay circuit 242, RE processing circuit 240 delays image density data of first one scanning line in the above-mentioned image density data of three scanning lines, which are sent scanning line by line, by 2 line scanning time, and delays image density data of middle one scanning line, by one line scanning time, but does not delay image density data of the last one scanning line. In addition, with 1 clock delay circuit 243, RE processing circuit 240 delays each image density data by one or two standard clock and sends out all image density data of pixels adjacent to a pixel of interest and the pixel of interest to operation circuit 241 at a time.

[0056]

In operation circuit 241, the above-mentioned RE process is performed and density data of a small pixel is obtained. First, density distribution within one pixel is obtained as below.

[0057]

Density data of a small pixel obtained is divided into a small scanning line including 1, s2, s3 ... in Figure 10, a small scanning line including s4, s5, s6 ..., and a small scanning line including s7, s8, s9 .... These three scanning lines of the small pixels correspond to one scanning line of the original pixel.

[0058]

Operation circuit 241 further operates to obtain record location data (8 bits) from average density within a unit pixel of each small scanning line (8 bits) and centroid location of density data within an original one pixel of each small scanning line. Digital signal of average density data (hereinafter called "density data") is output from output terminals O4, O5, O6 via MTF correction circuit 232, γ correction circuit 233, latch circuit 234 into respective input terminals Id of modulation circuits 260A-260C, and record location data is output from output terminals OA-OC into respective input terminals Ik of modulation circuits 260A-260C. In other words, when a density centroid of s1, s2, s3 of pixel m5 (first small scanning line) is at the left end of s1, a digital signal of the minimum value (0) is output from output terminal OA into modulation circuit 260A, when the density centroid is at the center of s2, digital signal of the middle value (128) is output from output terminal OA into modulation circuit 260A, and when a density centroid is at the right end of s3, record location data corresponding to the above-mentioned density centroid location, which is a digital signal of the maximum value (255) is output from output terminal OA into modulation circuit 260A. In the same way, record location data of a second small scanning line depending on density centroid locations of s4, s5, s6 of pixel m5 (in this case, a small scanning line in the center) is output from output terminal

OB into modulation circuit 260B and record location data of a third small scanning line depending on density centroid locations of s7, s8, s9 of pixel m5 is output from output terminal OC into modulation circuit 260C.

[0059]

When an image is a halftone region, a signal from image determination circuit 231 activates two pixels averaging circuit 221 and image density data averaged for two pixels adjoining in the main scanning direction into RE processing circuit 240, and the RE process is performed where two pixels of the original pixel are considered as one pixel.

[0060]

On the other hand, image determination circuit 231 compares image data of a pixel of interest with a predetermined first threshold of a low value and a predetermined second threshold of a high value. If the data is determined to be outside the first and second threshold, image determination circuit 231 sends the signal to RE processing circuit 240. Image determination circuit 231 causes RE processing circuit 240 to send record location data (128), in which a record location is in the center for all colors, to modulation circuit 260A-260C but does not activate MTF correction circuit 232. Therefore, average density data for the above-mentioned each small scanning line is not subject to correction by MTF correction circuit 232. The average density data is corrected with γ correction

circuit 233 and output into modulation circuit 260A-260C via latch circuit 234.

[0061]

As a result, in a highlighted region and a high density region, neither MTF correction nor location modulation is performed, which enables forming of a highly uniform noiseless image.

[0062]

Under the above-mentioned condition, image determination circuit 231 also determines whether an image is a text region or a halftone region in general. This determination is based on density variation within a pixel of 16 × 16 including a pixel of interest. If the image is a region of large density variation, image determination circuit 231 determines that the pixel of interest is a text region. If the image is a region of small density variation, image determination circuit 231 determines that the pixel of interest is a halftone region. If the determined region result differs only for a small region, for example, if a halftone region is isolated in a text region, the region is determined to be a text. It is determined in the same manner as in the halftone region. If image determination circuit 231 determines that the image is a text or a text region of line art, it outputs a selection signal to output standard clock DCK_0 as an image clock to select circuit 282, and outputs density data as it is into modulation circuits 260A-260C via latch circuit 234 without activating MTF

correction circuit 232 and γ correction circuit 233. This reproduces a clear text or an edge part with no change in color tone. If image determination circuit 231 determines that the image is a halftone region, it outputs to select circuit 282 a selection signal to output double cycle clock DCK_1 as an image clock.

[0063]

With the above-mentioned processes, an image with many grades can be formed, while providing a text image with sharpness and tightness in a halftone region.

[0064]

Preferably, a visually matching G component or achromatic color data including the G component is used as image density data used in record location determination and an RE process. In the embodiment, what converted into density data of a particular color, for example, R + 2G + B (R refers to density data of red, G refers to density data of green, and B refers to density data of blue here). For convenience, density data of (R + 2G + B) is represented by N.

[0065]

By making a record location common to all component colors, the embodiment can guarantee grades of an image and prevent change of color. For the same reason, the above-mentioned N is used for image density data used in image determination circuit 231 as data common to all component colors in the embodiment.

[0066]

Modulation circuits 260A-260C generates a modulation signal, which is a pulse-width-modulated writing pulse based on record location modulation and density data corresponding to record location data from the above-mentioned record location data and density data. Then it outputs the modulation signals for three of small scanning lines lying sequentially in parallel (one line of density data of the original image) are output to raster scanning circuit 300 as one unit.

[0067]

Next, configuration and operation of modulation circuit 260 shown in Figure 2 will be described with reference to a flow chart of Figure 3 and a time chart of Figure 4.

[0068]

A digital programmable delay generator AD 9501 from Analog Devices, for example, may be used for programmable delay generation circuit A262 and programmable delay generation circuit B263 shown in Figure 2. This delay generation circuit is a digital programmable delay generator and is a delay circuit that can program a delay time of an input pulse. These circuits are configured that the maximum delay amount is determined by an external condenser C and resistances R1, R2.

[0069]

An image clock from select circuit 282, an image determination signal from image determination circuit 231,

and record location data and density data processed and output by RE processing circuit 240 are input into input terminals Ic, Ih, Ik, and Id of modulation circuit 260, respectively.

[0070]

The image determination signal is a signal, which is turned ON in a text region and turned OFF in a halftone region. When the signal is ON, Tr1 and Tr2 are conducting and a resistance value is small, as the resistance value, which determines the above-mentioned maximum delay amount, is a combined resistance of resistance R1 and resistance R2. When the signal is OFF, the resistance value is big, as it is a value of resistance R1. It is set to the same maximum delay amount as a cycle of standard clock DCK_0 for a text region, and it is set to the same maximum delay amount as a cycle of double cycle clock DCK_1 for halftone region. A standard clock DCK_0 is input as an image clock into a terminal Ic in a text region, and a double cycle clock DCK_1 is input in a halftone region. Therefore, a modulation signal of a unit of the original pixel (by dot) is generated for a text region, and a modulation signal in unit of two dots is generated for a halftone region.

[0071]

Generation of pulse start data and pulse end data is performed according to a flow chart shown in Figure 3(a). When the above-mentioned various signals and record location data and density data is input into pulse start/end

information generation circuit 261 (step 1), it is determined whether the value K in record location data is 128 or more at first (step 2). If the value is determined 128 or more, then it is determined whether a half of the value D in density data is (255 - K) or more (step 3). If the result is YES, the operation continues to step 4, where the value A of pulse start data is set {A = 255 - D} and the value B of pulse end data is set {B = 255}.

[0072]

If it is not {K ≥ 128} at step 2, the operation continues to step 5, where it is determined whether a half of D is K or more (step 5). If the result is YES, the value A of pulse start data is set {A = 0} and the value B of pulse end data is set {B = D} (step 6).

[0073]

When it is determined NO at step 3, i.e., {D/2 < (255 - K)} and when it is determined NO at step 5, i.e., {D/2 < K}, the operation continues to step 7, where the value A of pulse start data and the value B of pulse end data are set {A = K - D/2} and {B = K + D/2}, respectively.

[0074]

D, K, A, B, which represent density data, record location data, pulse start data, and pulse end data, respectively, are illustrated as Figure 3(b). Each data comprises eight bits with a starting point of a cycle being 0 and an end point being 255. Figure 3 shows pulse waveforms that appears when laser writing device 430 is writing at high level.

[0075]

Relation between values A and B for pulse start data and pulse end data and values K and D for record location data and density data is shown below.

[0076]

K = 1/2 (B - A) + A ...(value at the center location of a pulse)

D = B - A ... ... (value of a pulse width)

Figure 4 is a time chart for generating a writing pulse, the modulation signal. (a) in Figure 4 is an image clock, (b) is density data, (c) is record location data, (d) is pulse start data, (e) is pulse end data, (f) is trigger pulse t1, described later, (g) is trigger pulse t2, described later, and (h) is a pulse of the above-mentioned modulated writing signal.

[0077]

The above-mentioned pulse start data is input into programmable delay generator A262, which causes a trigger pulse t1 delayed by A from the start point of the cycle to be sent to D-flip flop 264. On the other hand, pulse end data is input into programmable delay generator B263, which causes a trigger pulse t2 delayed by B from the start point of the cycle to be input into D- flip flop 264. Consequently, a writing pulse shown in Figure 4 (h) is generated and sent from Q terminal of D- flip flop into laser writing device 430.

[0078]

As mentioned above, for pixels in a low density part and a high density part, record location data is regarded as 128 and record location modulation is not performed. As the result of the above-mentioned modulation signal generation, a text and a line art are reproduced clearly. This is because, in a region of greater density variation, record location modulation is performed to displace the location of small dots in n line within a pixel of interest to a location in the direction of the line of the original text or the line art as shown in Figure 6 based on density data of the original adjacent pixels.

[0105]

[Advantages of the Invention]

As described above, modulation means is provided to obtain record location data corresponding to density centroid location of image data, on which RE process is performed to distribute density within a pixel of interest according to distribution of density data of adjacent pixels including a pixel of interest and average density data for each small scanning line; and, based on the data, to generate a writing pulse with no effect on adjacent pixels, which are subject to record location modulation and pulse width modulation. Thus, according to density data of an image of interest, a pixel of interest included in a particular density is divided into small pixels, and density of each of the small pixels is not subject to record location modulation in its low density part or high density part. As a consequence, a high quality record image is provided with no writing dot sticking out into other pixels and none of other pixels being affected. Additionally, image determination is performed by image determination circuit; for a text region, short cycled, dot by dot writing is performed, and for a halftone region, long cycled writing in the unit of two dots is performed to perform color image record. Thus, a distinguished image forming device to improve sharpness of a color image containing scanner, CG, font data, or the like without affecting color is provided. The use of high γ photo conductor further improves the effect.

Figure 1

#1 FONT DATA STORAGE CIRCUIT

120 FONT DATA GENERATION CIRCUIT

140 INTERPOLATING DATA GENERATION CIRCUIT

110 INPUT CIRCUIT

151 COLOR SCANNER

154 MASKING UCR

153 DENSITY CONVERSION

210 IMAGE DENSITY DATA RECORD CIRCUIT

220 READING CIRCUIT

221 TWO PIXELS AVERAGING CIRCUIT

231 IMAGE DETERMINATION CIRCUIT

232 MTF CORRECTION CIRCUIT

233 γ CORRECTION CIRCUIT

234 LATCH CIRCUIT

240 RE PROCESSING CIRCUIT

260A MODULATION CIRCUIT

260B MODULATION CIRCUIT

260C MODULATION CIRCUIT

280 STANDARD CLOCK GENERATION CIRCUIT

281 DOUBLE CLOCK GENERATION CIRCUIT

282 SELECT CIRCUIT

311 δ DELAY CIRCUIT

312 2δ DELAY CIRCUIT

301A LASER DRIVER

301B LASER DRIVER

301C LASER DRIVE

Figure 2

#1 IMAGE CLOCK

#2 IMAGE DETERMINATION VALUE

#3 RECORD LOCATION DATA

#4 DENSITY DATA

#5 OUTPUT TERMINAL

#6 D-FLIP FLOP

262 PROGRAMMABLE TRIGGER DELAY GENERATION CIRCUIT A

263 PROGRAMMABLE TRIGGER DELAY GENERATION CIRCUIT B

261 PULSE START/END INFORMATION GENERATION CIRCUIT

Figure 3(a)

#1 START

1 INPUT RECORD LOCATION DATA (K) AND DENSITY DATA (D)

Figure 3(b)

#1 ONE CYCLE

#2 WRITING PULSE

D: DENSITY DATA

K: RECORD LOCATION DATA

Figure 4

(a) IMAGE CLOCK

(b) DENSITY DATA

(c) RECORD LOCATION DATA

(d) PULSE START DATA

(e) PULSE END DATA

(f) TRIGGER PULSE t1

(g) TRIGGER PULSE t2

(h) WRITING PULSE

Figure 5

#1 RE PROCESSING CIRCUIT

221 TWO PIXELS AVERAGING CIRCUIT

241 OPERATION CIRCUIT

242 ONE LINE DELAY CIRCUIT

243 ONE CLOCK DELAY CIRCUIT

#2 TO 260A

#3 TO 260B

#4 TO 260C

Figure 12(b)

#1 REGION ASSOCIATED WITH S1

#2 REGION ASSOCIATED WITH S2

#3 REGION ASSOCIATED WITH S3

#4 REGION ASSOCIATED WITH S4

Figure 13(b)

#1 REGION ASSOCIATED WITH S1

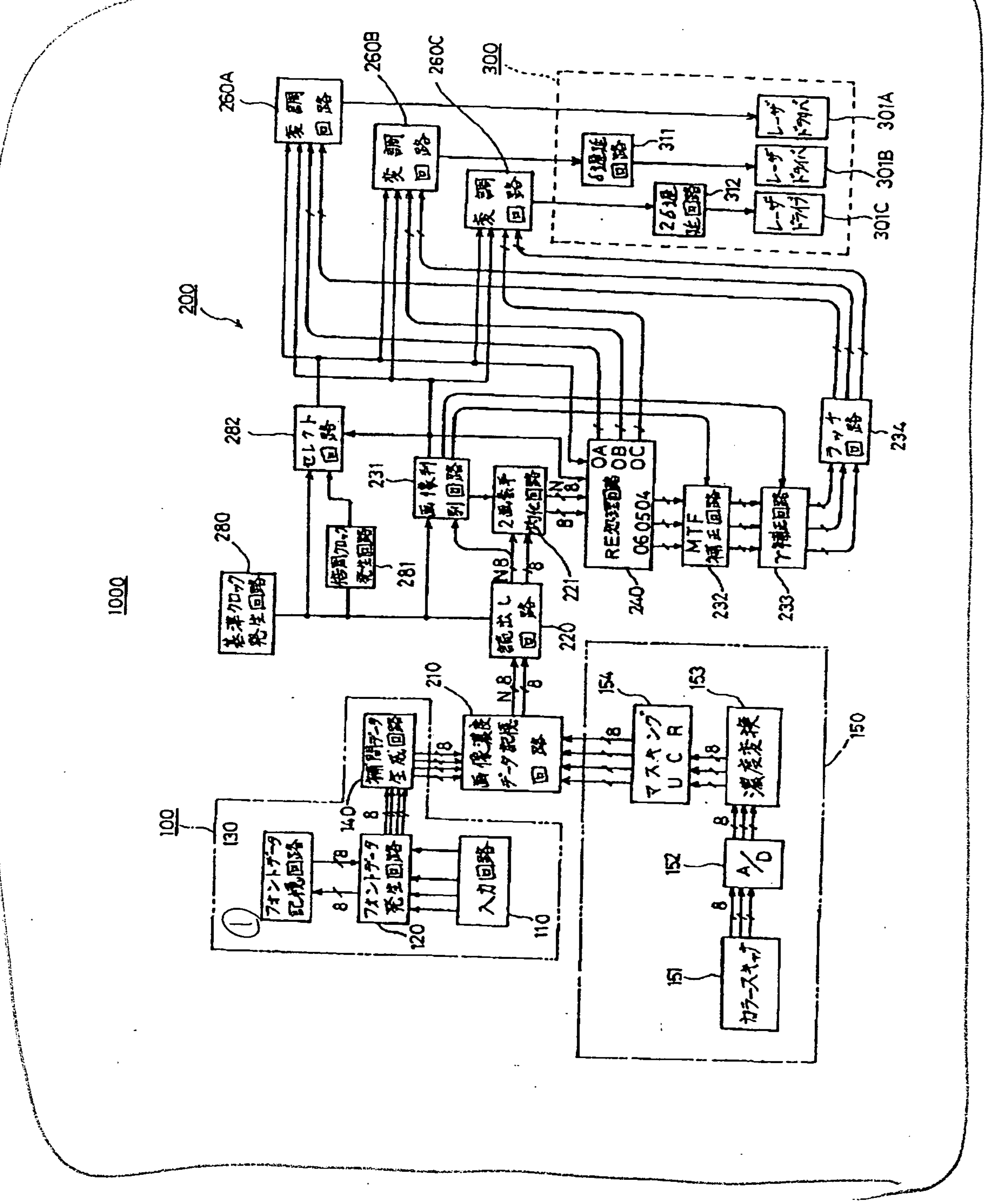
#2 REGION ASSOCIATED WITH S2

#3 REGION ASSOCIATED WITH S3

#4 REGION ASSOCIATED WITH S4

Fig. 1

【図1】



【図2】 Fig.2

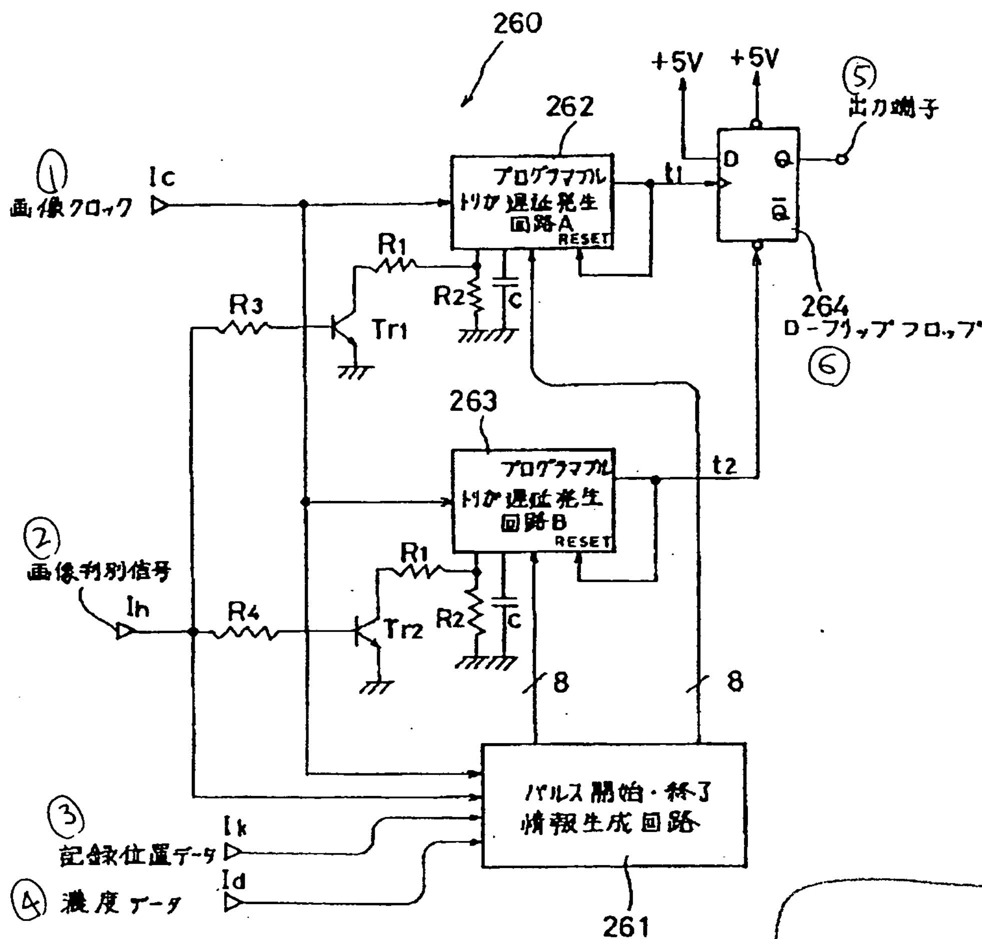
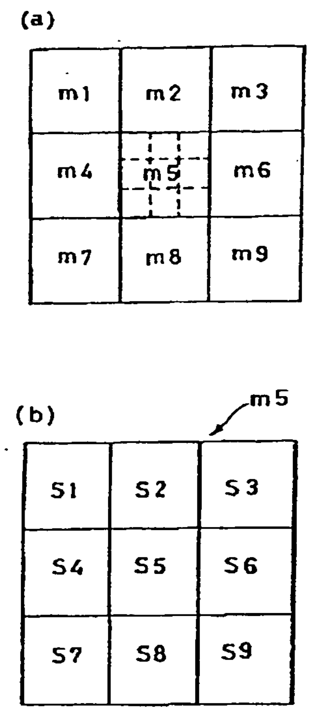
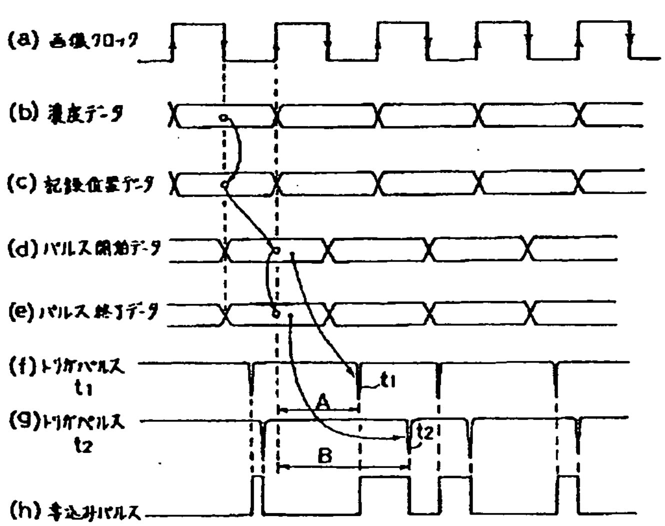


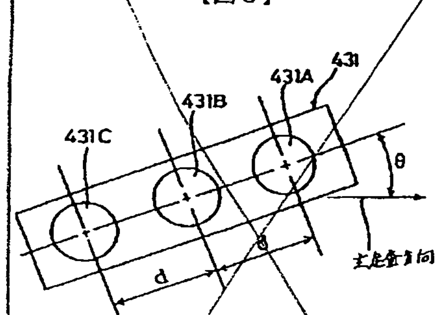
Fig.10 【図10】



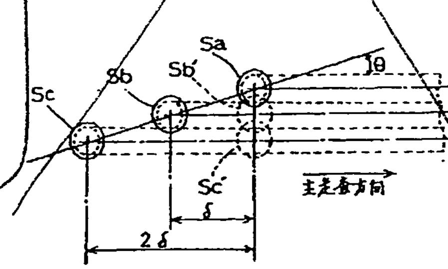
【図4】 Fig.4



【図8】

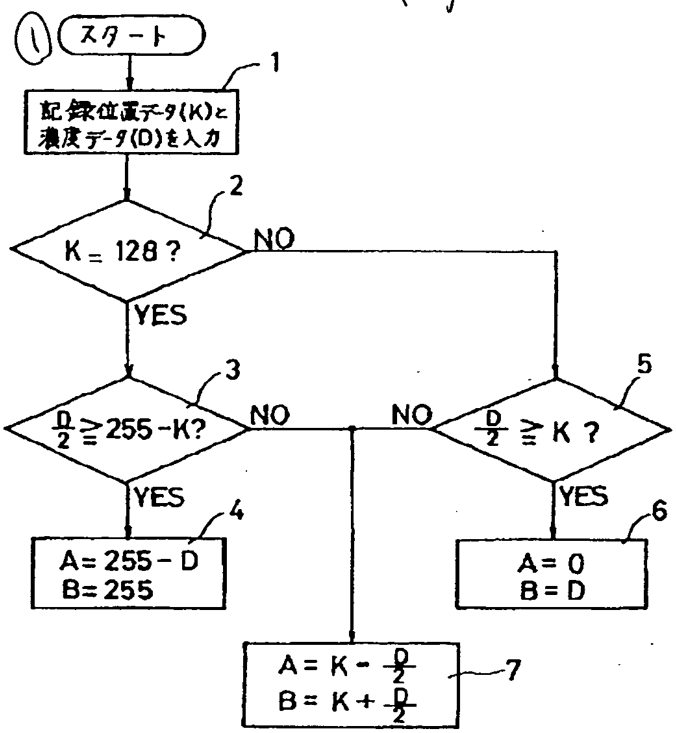


【図9】

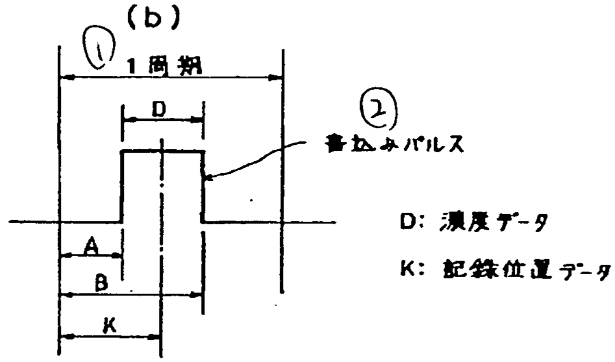


【図3】　Fig.3

(a)



(b)



【図11】　Fig.11

(a)

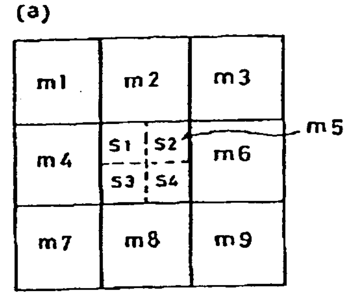
m1=226	m2=251	m3=8
m4=200	m5=45	m6=7
m7=190	m8=8	m9=2

(b)　m5

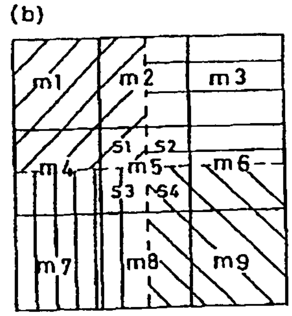
S1=71	S2=76	S3=24
S4=65	S5=32	S6=24
S7=63	S8=24	S9=22

【図12】　Fig.12

(a)

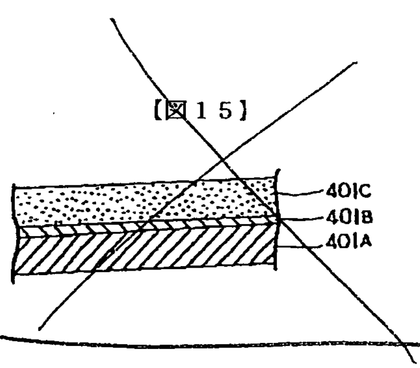


(b)



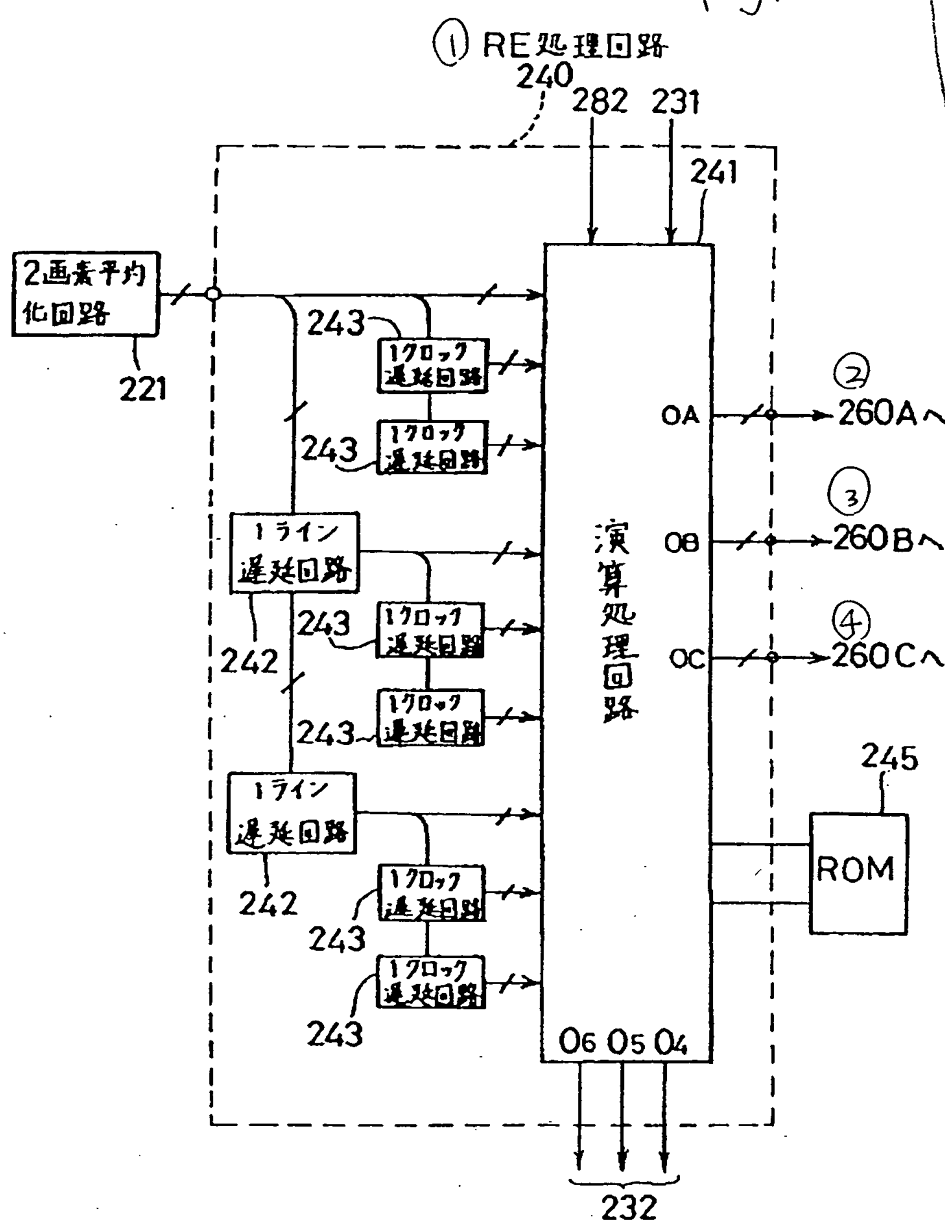
① ⫽:S1に関係する領域　☰:S2に関係する領域②
③ |||:S3に関係する領域　⧵⧵:S4に関係する領域④

【図15】

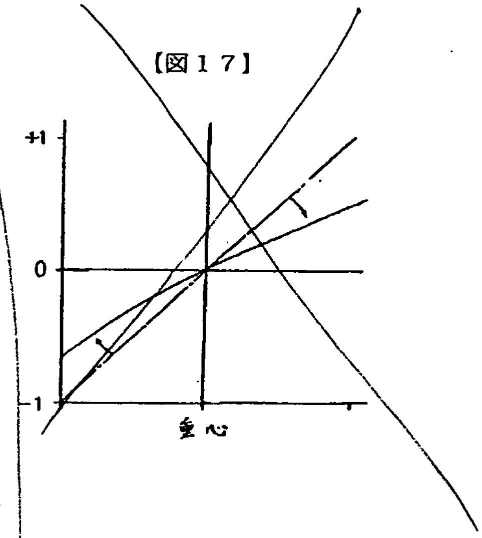


【図５】

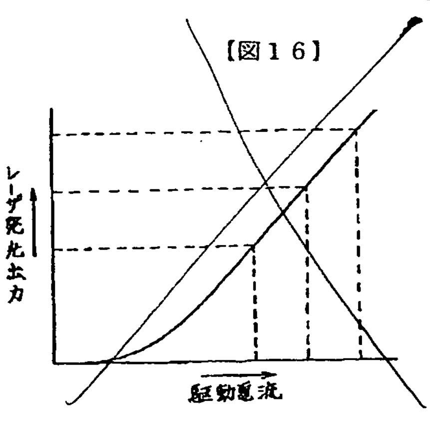
Fig.5



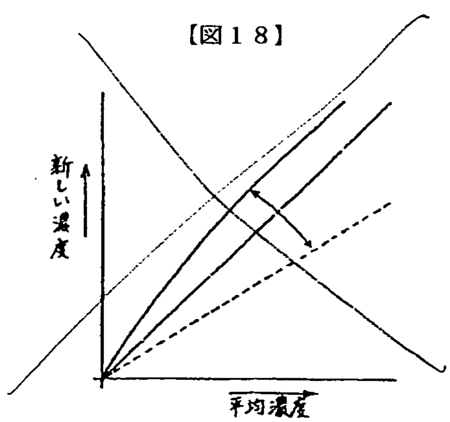
【図１７】



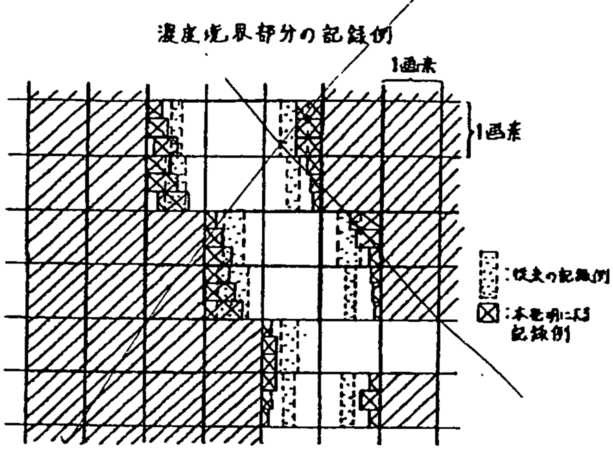
【図１６】



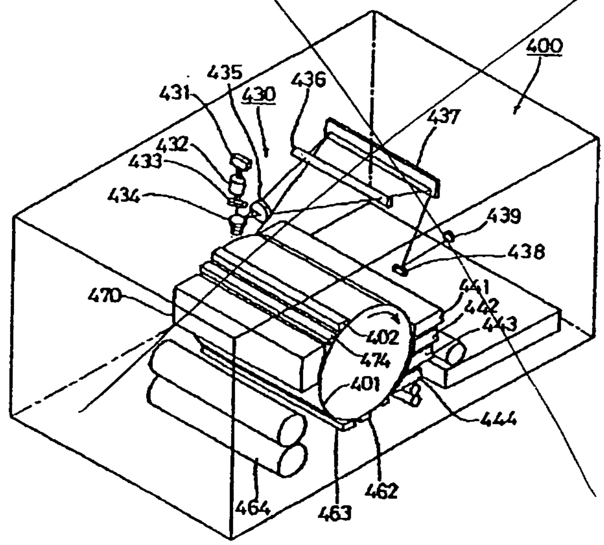
【図１８】



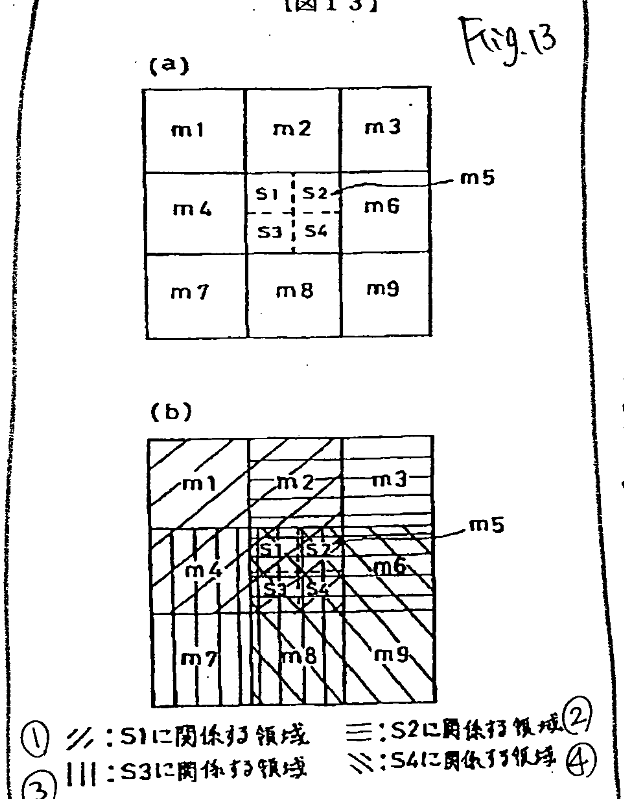
【図６】



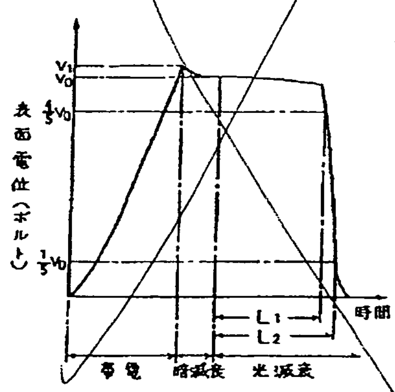
【図７】



【図１３】



【図１４】



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